FUZE PREDICTION

151. Fuzes are continuously predicted from a log range/time plot as described in Part (A), Chapter VI. The plotting paper moves at a constant speed of six inches a minute and is automatically marked every thirty seconds by a pen timing marker on the right of the plot. The plot is driven off the table constant speed motor through the paper drive cut-out clutch, which is engaged when the starting lever is put to " Stand-by " (para. 117 above). This clutch is provided as the constant speed motor is required to run continuously to operate the oil motor dither shaft (*see* Chapter VII).

THE RANGE/HEIGHT CONVERSION UNIT (Plate 13)

152. The principle of the range/height conversion unit is described in Chapter VI, paras. 144 to 150, and illustrated in Plate 7, Fig. 2 of Part (A) of this handbook. The gear in H.A.C.S. III is shown in Plate 13 of this part. Log height (orange) from the dual motor is fed into the table through a slipping clutch and

(i) positions the orange pointer in the log height dial ;

(ii) is fed into the conversion gear.

153. The **slipping clutch** is fitted to prevent undue strain on the range/height conversion unit when the range limit stops are reached or when the dual motor is working at high speed. The clutch will operate when either the log height or angle of sight drives work the gear against the stops.

154. The clutch is adjusted by the manufacturers to render when a definite driving torque is imposed and, should it develop a tendency to slip, the spring load must not be increased, but the cause of the extra load on the gear investigated. Unnecessary movement of the rangefinder working head or alteration in angle of sight when the gear is on the stops is to be avoided.

155. **Present angle of sight** is obtained from a combination of director setting and roll (*see* Plates 4 and 6). The " A " element in the gyro roll corrector controls the yellow roll oil motor which runs and

(i) feeds roll differentially into the director setting drive to produce present angle of sight (brown) ;

(ii) drives the roll transmitter to recentre the " A " element hunter in the gyro roll corrector ;

(iii) positions a pointer on the roll dial (yellow).

156. Mechanical **stop gear** is fitted to limit the roll drive to $\pm 15°$ and differential stop gear to limit the future angle of sight between $-10°$ and $+90°$. The nut on the shaft of this gear is rotated for vertical deflection (pink) and driven along the shaft by director setting plus roll, the stops thus operating for future angle of sight.

When G.R.U.B. is fitted and the elevation drive to the azimuth gear box is S_p instead of S_f it will be necessary to introduce S_p stop gear into the table as well as S_f to protect the gear. Owing to the limited space available for the stops the limits of each stop gear will then be 0° to 90°.

157. The present angle of sight drive has vertical deflection added differentially to produce **future angle of sight** to operate the projection unit (para. 43 above), the azimuth conversion gear (para. 64 above), the own course and speed correction linkage (para. 74 (*b*) above) and the tangent elevation drum (para. 81 above). When G.R.U.B. is fitted the elevation drive to the gear will be S_p instead of S_f and an S_f " M " type transmitter will be included.

158. A **roll stand-by handwheel** (yellow), with autolock to prevent a back drive, is fitted for lining up and for setting the roll to zero or a mean position of the list on the ship by the roll dial in the event of a failure of the oil motor. The hand power clutch unclutches the hand drive when put to " power " and unclutches, sprags and inserts a shock absorber in the oil motor drive when put to " hand."

159. Present angle of sight (para, 155 above) is converted into log sin S_p by a difference cam (*see* Plate 4), and this is added differentially to the log height drive from the dual motor (para. 152 above). This gives **observed log range** (blue), which

(i) drives the observed log range pricker screw for the plot ;

(ii) offsets the " A " element hunter of the $\frac{1}{R}$ oil motor.

160. The blue $\frac{1}{R}$ oil motor runs and

(i) drives the $\frac{1}{R}$ transmitter controlling the rangefinder deflecting prism and G.R.U.B. where fitted ;

(ii) the drive is converted into log R by a difference cam to centre the log range " A " element hunter.

161. In a few early tables mechanical **stop gears** are fitted to limit the scope of the log range drive. They are arranged to operate at 2,000 yards and 20,000 yards with $\frac{1}{R}$ limited correspondingly. In all later tables the limits of log range and $\frac{1}{R}$ are 2,100 yards to 20,000 yards. The low range limit was increased in order to obviate any possibility of the tables and rangefinders getting out of step when hitting the low range stops if the table and rangefinder were not exactly aligned.

162. An alternative $\frac{1}{R}$ **hand drive,** with sprag gear and shock absorber unit, is fitted for use in the event of failure of the $\frac{1}{R}$ oil motor. When using the hand drive, the " A " element of the log range hunter must be kept central, *i.e.*, the line on the moving disc in coincidence with the two fixed lines. An arrow on the moving disc indicates which way to turn the hand drive, should the centring line be out of sight.

163. The range/height conversion gear is designed to give **true conversion** between 10° and 80° present angle of sight.

LOW ANGLE RANGING

164. The arrangements for low angle ranging are dealt with in Chapter VI.

THE OBSERVED PLOT

165. The observed log R pricker screw is driven direct from the log R drive in the range/height conversion unit (para. 159 above). The pricker is electrically operated by the rangetaker's cut push and a contactor driven off the table constant speed drive (para. 176 below). For speed of pricker, *see* para. 176.

166. The scope of the observed log range screw is from 2,100 yards to 20,000 yards, but the scope of the plot is only from 2,000 yards to 15,000 yards. Above the latter limit the observed prickers work in the usual way, but are off the plot. The scope of the observed log range screw is 2,100 yards to 20,000 yards except in a few early tables referred to in para. 161.

THE GENERATED PLOT AND THE RATE UNIT (Plates 13 and 14)

167. The generated plot is obtained from a combination of hand setting of log height **(follow log height)**, red, and the value of log sin S_p (green) generated by the **rate unit.**

168. **Follow Log H.** The orange pointer in the height dial is set for observed log height by the drive from the dual motor (para. 152 above). The red pointer in the dial, the " black " pointer, can be aligned with the orange by the follow log height handwheel which

(i) feeds follow log height for the generated plot into the range/height conversion gear ;

(ii) positions the three-dimensional time difference cam for log height (*see* para. 181 below) ;

(iii) rotates the A.P.V. drum for log height (para. 55 above).

Note :—Log height is not an accurate log value below 1,000 feet.

An autolock is fitted in the handwheel and mechanical stop gearing limits the hand settings to between 0 and 30,000 feet.

169. A diagrammatic arrangement of the **rate unit** is shown on Plate 14. The observed log sin S_p drive (mauve) from the range/height conversion unit (para. 159 above) positions the red pointers on the log sin angle of sight dial. The corresponding black pointers are driven by a combination of hand setting of log sin S_p from the angle of sight tuning handwheel and the change of log sin S_p generated by the rate unit.

170. The rate disc in the unit is driven from the table constant speed drive. By means of the rate setting knob the variable speed gear balls can be positioned on the disc so as to impart a generated rate which drives the black pointers in the log sin angle of sight dial at the same speed as the red (observed) pointers. The pointers can be aligned by the tuning handwheel.

170(a) - see slip

171. The ordinary fast and slow black pointers are fitted, but instead of a fast red pointer there is a red pointer disc. This is marked with a zero position and a number of lines and the rates of change of angle of sight can be compared by noting the movement of the fast black pointer relative to any of the graduations on the red pointer disc, without necessitating exact alignment.

172. The generated (or " smoothed ") log sin S_p from the rate unit is added differentially to hand setting of follow log height (para. 168 above) to give **generated log range** which drives the generated log R pricker screw. The scope of the generated log R screw is from 2,000 yards to 15,000 yards and **cut-out gear** is fitted to the rate unit which, at these limits, lifts the roller clear of the variable speed gear balls. Generation of rate of change of angle of sight can also be stopped by means of a hand cut-out, which lifts the roller clear in a similar way.

173. The generated plot pricker is electrically operated by a contactor driven off the table constant speed drive (para. 176 below) and makes a transverse slot in the paper. The generated plot can be switched " on " or " off " by a two-position switch on the table and is therefore completely under the control of the plot operator. For speed of pricker, *see* para. 176.

174. An **angle of sight cut lamp** is fitted near the angle of sight dial. It is controlled from a push in the director and should burn whenever the director layer is on the target. If the target is obscured the director layer extinguishes the cut lamp, and the director setting operator at the table, by means of his stand-by director setting handwheel, follows the change of angle of sight generated by the rate unit, thus transmitting generated director setting to the repeat receiver of the director. The director layer follows the pointer in his repeat receiver and is thus kept on approximately for elevation provided the target maintains a steady course and speed.

Third Screw

175. All tables will be fitted with a **third log range screw** driven by " M " type transmission from the R.D.F. set of the ship. In order to reduce the load on the motor the pricker is mounted on a light carriage and worked by a long bar running the length of the plot, actuated by a solenoid at each end. The pricker makes a round hole in the plot and the plot is controlled by a separate " on " and " off " switch. For speed of pricker, *see* para. 176.

A few tables receive range in equal steps and the screws are therefore cut in a logarithmic spiral to convert the ranges to log R to suit the plot. Other tables receive range in steps of log R and are therefore cut to uniform pitch.

LOG R PRICKERS (Plate 15)

176. The observed and generated prickers, which are identical in construction (and also the pricker of the third screw), are carried on guide bars and traversed by the screwed shafts. They are operated by solenoids which pull down one end of the rockers against the return springs, which normally hold the prickers clear of the plot. The solenoids of the first two are energised through the brushes and slider bars which run the whole length of the plot and are controlled by the contactor on the constant speed drive. Those for the third screw are fixed one at each end and operate a rocker bar.

Prickers Speed

Observed log R pricker ..	120 contacts per minute.
Generated log R pricker ..	30 contacts per minute.
Third log R pricker	60 contacts per minute.

FUZE PREDICTION GEAR (Plate 16)

177. A general description of the improved fuze prediction gear is given in Part (A), Chapter VI. The gear is shown on Plate 16 of this pamphlet.

178. The plot operator moves the fuze range handwheel (blue) until the cursor head is in the estimated future position of the target as indicated by the plot and cursor wire. By so doing he

(i) sets a fuze range on the main element of the **fuze range receiver;**

(ii) positions the range pivot in the multiplying link gear of the **fuze set back corrector;**

(iii) positions the follower unit on the yellow three dimensional **time difference cam;**

(iv) feeds fuze range into the **time of flight output differential;**

(v) drives the blue log fuze range **pin wheel cam.**

179. **Mechanical stops** limit the fuze range settings to between 1,500 yards and 15,000 yards and the handwheel is frictionally connected to the gearing to allow it to render on reaching the stops by means of a slipping clutch on the fuze range handwheel.

180. The **pin wheel cam** converts the fuze range into log fuze range. The driving pinion is rotated for fuze range by the driving sleeve and the pin track is so arranged that the pin wheel is rotated for log fuze range. This movement is communicated through a bevel wheel to the ballistic differential where the ballistic height correction (orange) is added. The resultant movement (log fuze range corrected for ballistics) is transmitted to the pale green log fuze range traversing screw and positions the prediction cursor transversely on the plot.

181. The three dimensional **time difference cam** is rotated by the yellow hand drive of follow log height (para. 168 above). The follower unit (red), which is traversed by the fuze range handwheel, carries a rack and hardened steel ball. The rack engages in the red time difference shaft, which, under the action of a spring, is always tending to drive the rack in a direction which forces the ball against the surface of the solid cam. The cam is so constructed that the movement allowed to the ball represents the difference between time of flight and a straight line function of fuze range (*see* Part (A), Appendix I), and this movement is communicated through the rack and shaft to the **time of flight output differential,** where it is added to a movement representing fuze range to give time of flight (mauve).

182. The time of flight (mauve) so obtained

(i) has dead time (blue) from the fuze and firing interval clock added to it (para. 129 above), the resultant movement (pink) driving the splined shaft which, through a pinion and rack, moves the prediction cursor up and down the plot;

(ii) has a correction from the **time to fuze difference cam** applied to it, *see* para. 183. The resultant fuze number has the fuze set back correction (para. 193 below) applied to it differentially and positions the pointer (green) in the **fuze number dial** and operates the sensitive side of an electrical hunter which controls the power motor in the **bulkhead fuze number transmission unit.** The hunter is recentred by " M " type transmission from the bulkhead unit.

" 183. In tables graduated for 4-in. Mark V ballistics no time to fuze difference cam is fitted." *(G. 02557/43.—C.A.F.O. P.298/43.)*

184. In earlier tables a **change speed gear** is incorporated in the drive before it reaches the hunter, for changing the ratio of fuze number transmitted when firing sub-calibre.

185. A **paper marking device** is fitted to the centre of the prediction cursor head. By it a mark, which represents an estimated future position of the target, can be made on the plot whenever the load lamp burns and by comparing the marks with the developed plot a measure of the accuracy of prediction can be obtained.

186. The **bulkhead fuze number transmission unit** (Plates 4 and 18) contains :—

(i) A power motor, controlled by the fuze number hunter in the table (para. 182 above), driving " M " type transmitters, one for recentring the hunter and one for transmitting fuze numbers to the guns.

(ii) An alternative hand drive in case the power motor breaks down.

(iii) A change speed gear and fuze correction drum for use when firing reduced charges and/or alternative fuzes. Earlier units which are not fitted with this gear are being replaced by units of the later type.

187. Over the bulkhead unit are two fuze number repeat dials, one showing the fuze number transmitted from the table and the other the fuze number transmitted to the guns.

188. The procedure for changing fuzes and/or charges is given on the cover of the bulkhead unit and is as follows :—

To change from 206 to 401 Fuze

Set " hand " or " power " clutch to " hand " position.
Rotate " stand-by " handwheel to zero fuze stop.
Release change fuze lever—set to 401 fuze position and lock.
Set " hand " or " power " clutch to " power " position.
Use fuze difference handwheel to follow height curve on chart.

To change from 401 to 206 Fuze

Rotate fuze difference handwheel to zero stop.
Set " hand " or " power " clutch to " hand " position.
Rotate " stand-by " handwheel to zero fuze stop.
Release change fuze lever—set to 206 fuze position and lock.
Set " hand " or " power " clutch to " power " position.

189. When transmitting fuze numbers by hand, the operator works the handle to set on the table fuze number repeat dial the fuze number showing on the fuze number dial on the table.

190. When firing non-standard fuzes or reduced charges the fuze number transmitted from the table is multiplied by gearing and an additional correction is added differentially to drive the gun fuze number transmitter. This correction is obtained by an operator positioning a pointer according to height on the fuze correction drum in the unit.

BALLISTIC HEIGHT AND FUZE SET BACK CORRECTORS (Plates 16 and 17)

191. The **ballistic height corrector** has been described in Part (A), Chapter VI. Two typical arrangements of the corrector strips and dials are shown on Plate 17. It will be noted that the inner ballistic height correction dial is common to all guns and fuzes, since it simply *applies a percentage range correction* irrespective of whether the necessity for the correction is ballistic or not. To use the corrector under normal conditions set the cursor against the mean M.V. of the gun, set the temperature of the charge opposite the cursor and set the residual ballistic height correction opposite the standard temperature.

192. It will be seen from Plate 16 that the ballistic height correction is applied to the prediction cursor fuze range drive and that therefore the fuze range hand-wheel must be driven for corrected fuze range and this is used throughout.

193. The **fuze set back corrector** has been described in Part (A), Chapter VI, and is set in a similar manner to the ballistic height corrector. Typical arrangements of the corrector and a diagram of the link gear are shown on Plate 17. As in the case of the ballistic height corrector it will be noted that the inner dial is common to all guns and fuzes and simply *applies a percentage fuze correction.*

194. The link gear is shown diagrammatically on Plate 16. Hand setting of percentage fuze set back correction transmits a transverse movement to one end of the pink multiplying link and hand setting of fuze range positions the blue pivot of the link so that the free end of the link is moved a distance representing the product of percentage fuze correction and fuze range (*i.e.*, a fuze range correction). This movement is imparted to the pink result quadrant which drives into a differential where the correction is added to the fuze number drive from the time to fuze difference cam (para. 182 (ii) above). With time mechanical fuzes, fuze number is very nearly a straight line function of fuze range and the gearing is so arranged that, for all practical purposes, a percentage fuze number correction is applied.

H.A./L.A. AND SURFACE FIRING ARRANGEMENTS

211. H.A.C.S. III is designed for H.A. fire, but it is generally possible for the H.A. armament to be controlled and fired from the H.A. director at surface targets. H.A.C.S. IIIc is designed for use in ships which have a combined H.A./L.A. armament, intended primarily for use in H.A. (such as "C" class cruisers converted to A.A. vessels), and has associated with it an Admiralty Fire Control Clock, Mark VIII, or a range transmitting clock and deflection calculator.

SURFACE FIRING WITH H.A.C.S. III

212. An initial rangefinder range can be obtained by obtaining a cut in the usual way and reading the range off the plot. Thereafter gun range is obtained from a Vickers clock and is set on the fuze range indicated by the curves on the T.E. drum for zero angle of sight.

213. **Deflection** is obtained from a Dumaresq and is set on the lateral deflection dial fitted close to the lateral deflection handwheel. The black pointer on this dial is worked mechanically by the lateral deflection handwheel and a red spotting pointer is frictionally connected to it.

214. The handwheel for H.A. fire is fitted to move in the same direction as the crosswires, *i.e.*, a clockwise rotation moves the crosswires to the right, thus applying left deflection. For surface fire a **reversing clutch** (Plate 19) is fitted to enable clockwise rotation to apply right deflection.

215. With the H.A./L.A. change lever in the H.A. position, the centre member of the differential is locked by the sliding clutch pinion. In the L.A. position this centre member is driven so as to reverse the drive to the gun training transmitter and to position the black pointer on the lateral deflection dial.

216. The slotted discs are driven at different speeds and the toes on the H.A./L.A. clutch can only pass through them when the deflection is to zero. As convergence and own ship corrections, and drift, affect the position of the lateral deflection crosswire, the following procedure should be adopted for changing over :—

To change from H.A. to L.A.

Put director training to hand, so that the director has freedom to train without disturbing the operation.

Set gun training to the same reading as director training by means of the lateral deflection handwheel.

Move lateral deflection handwheel until the pointer on it is exactly in line with the mark.

Put H.A./L.A. change lever to L.A.

Put director training clutch to "Power."

To change from L.A. to H.A.

Set zero lateral deflection on the dial.

Put H.A./L.A. change lever to "H.A."

217. Stops are fitted in the drive to the low angle deflection dial to limit the scope to 55 units right and left.

218. The **vertical deflection** handwheel has a locking lever which locks the handwheel in the zero position, the toes on the change lever engaging in the slots in the slotted discs, both of which are in line at zero vertical deflection.

219. **T.E. and dip.** Range is set on the T.E. drum, and the correct tangent elevation, + dip for the range in use, is thus added to director setting.

220. **Convergence** is applied by means of the gun training unit and convergence gear, where so fitted. Where the unit is not fitted no allowance is made (*see* para. 244 and Plate 5).

221. **Own speed** and **drift** corrections are applied on the Dumaresq.

222. A **layer's firing pistol** is fitted for surface fire in H.A./L.A. Directors.

223–226.

COMBINED H.A./L.A. ARMAMENT CONTROL

227. In ships in which the A.A. armament is the primary armament such as H.M.S. " Woolwich " or " C " class cruisers converted to A.A. vessels, the H.A.C.S. can be regarded as the main fire control system. For L.A. fire an additional calculating unit is fitted consisting either of a transmitting clock and deflection calculator or an A.F.C.C. Mark VIII. The system is then called H.A.C.S. IIIc.

228. The H.A.C.S. IIIc fitted with transmitting clock and deflection calculator is substantially the same as H.A.C.S. III with the addition of the following :—

(*a*) Rate officer's position in H.A. director tower including a seat and arm rests for support when holding glasses.

(*b*) A range dial, calibrated to suit the L.A. ammunition.

(*c*) Convergence correction for L.A. on to pointer of L.A. lateral deflection dial (in " Woolwich " only).

(*d*) Counterdrum receivers of gun range and deflection from range transmitting clock and deflection calculator.

(*e*) Additional flexible shaft drive of bearing from table to L.A. deflection calculator.

229. The range dial is carried in a bracket from the top of the table in a similar manner to the fuze range receiver. A mechanical connection is arranged from the T.E. handwheel to the pointer in the dial. The dial, which is graduated for range in values of tangent elevation plus dip, has a scope of 30° of T.E. The normal H.A.C.S. III table has only 21° on its T.E. drum, but where surface range dials are fitted the linear travel of the T.E. pointer is altered to 13·44 inches for the 21° and a " wrap up " of 9° is provided at the end of the drum. Thus no change-over or difference in procedure is necessary for L.A. fire.

230. The convergence mechanism for the deflection setting dial consists of the normal type of crank mechanism set for bearing by the training motor of the table with a hand setting of range in values of $\frac{1}{R}$. The mechanism offsets the dial of the deflection unit and it is necessary to reset the pointer to the deflection as received by the counterdrum.

Note.—In H.M.S. " Coventry " a special hand follow convergence unit was fitted and the ordinary convergence cam gear resultant in the own course speed and convergence linkage was locked at zero. The special unit applied convergence only to the gun training transmitters for a large displacement, and two transmitters were fitted to the tables in order to transmit to a larger number of guns ; no convergence was applied to gun elevation but two transmitters were fitted. Other " C " class cruisers have a L.A. convergence box.

H.A.C.S. IIIc and A.F.C.C. Mark VIII

231. The A.F.C.C. Mark VIII is operated in conjunction with the H.A.C.S. Mark IIIc in the low angle control of the Q.F., 4–inch, Marks XVI or XVI* guns as mounted in the " C " class cruisers re-armed as A.A. vessels (except " Coventry ").

232. The A.F.C.C., Mark VIII is described in C.B. 1886/34 (4). It is used purely as a calculating mechanism to produce :—

(1) Gun range and gun deflection for transmission to the guns.
(2) Tangent elevation and dip to be transmitted to H.A.C.S. IIIc.
(3) Gun deflection and drift to be transmitted to H.A.C.S. IIIc.

It is not designed to transmit gun elevation or gun training.

233. The change-over from H.A. to L.A. is effected by means of two change-over switches (Plate 23).

(1) **To change from H.A. to L.A.**

1. Put the F. and F.I. clock lever to " stop," set own speed to zero. and A.P.V. hard left. Centre deflection crosswires.
2. Put *both* change-over switches to " L.A."
3. Put the lateral deflection clutch to " L.A." (*see* para. 216). Care must be taken that this clutch is not forced.

(2) **To change from L.A. to H.A.**

1. Put both C.O.S. to H.A.
2. Set zero lateral deflection and put deflection clutch to " H.A."
3. Set own speed and A.P.V.

ELEVATION ARRANGEMENTS

Rangefinder Range

234. When the change-over switches are put to L.A. the rangefinder working head is connected to the $\frac{1}{R}$ oil motor and transmitter via the **interlinking hunter unit** on the bulkhead. This isolates the R/H conversion unit. The $\frac{1}{R}$ motor transmits to the deflecting prism in the R/F and to the range receiver beside the A.F.C.C. for tuning the clock.

The C.O.S. also connects the rangetaker's cut push to the cut lamp at the A.F.C.C. range receiver instead of the pricker on the H.A. plot.

In L.A. the fast transmission switch beside the working head is cut out.

Note.—It is advisable to put the C.O.S. over to L.A. before the director layer lays down on to the horizon ; if this is not done the range as produced by the range/height conversion unit runs to 20,000 yards and delay in getting a cut at normal ranges will result. On changing back to H.A. the R/H conversion unit takes charge and the $\frac{1}{R}$ transmitter runs the rangefinder scale and range receiver back to the range they were showing when last in H.A.

Tangent Elevation and Dip

235. T.E. is produced by a pin wheel cam in the clock ; dip is added differentially by a separate dip cam and the result is transmitted to a dial graduated for range on the H.A. table. Hand follow up by means of the T.E. handwheel produces T.E. and dip which is added mechanically to the director setting.

Director Setting

236. Director setting is received in the H.A. table only. A director setting receiver at the clock is operated by a transmission from the H.A. table.

Range Spotting Corrections

237. Range spotting corrections are applied at the large spotting handwheel of the A.F.C.C.

Vertical Deflection

238. The vertical deflection crosswire at the H.A. table is locked at zero (*see* para. 218).

Gun Elevation

239. Gun elevation is transmitted from the H.A. table as for H.A. fire. A gun elevation receiver at the clock is operated by this transmission.

240. The gun elevation receivers are of the types indicated in Appendix VIII.

(i) *M.V. and Temperature.*—Where corrected elevation receivers are supplied the mean M.V. of each pair of guns is set at the elevation receiver and corrected for range either by hand or by a motor in the receiver which is fed with range transmitted from the A.F.C.C.

In H.A. fire, range on the clock should be set to zero as M.V. and temperature are allowed for in the H.A. table.

(ii) *Dip.*—With F, Mark III receivers, a dip correction may be incorporated in the scales on the M.V. drum. With other types of receiver referred to in the appendix, dip from guns to standard level is not allowed for.

(iii) *Tilt.*—No allowance is made in the gun receivers (*see* paragraph 303)."

(*G. 07634/42.—C.A.F.O. P.276/42.*)

~~No allowance is made in the gun receivers (*see* para. 303).~~

TRAINING ARRANGEMENTS

241. Director Training

Director training is fed into the A.F.C.C. for calculating purposes only.

Line Spotting

242. Is carried out at the deflection spotting handwheel at the A.F.C.C.

Lateral Deflection

243. Lateral deflection, including corrections for own ship, enemy wind and drift are combined in the clock and transmitted electrically by the deflection handwheel to the red pointer of the L.A. deflection receiver at the H.A. table.

A clutch at the H.A. table is put to L.A. and the corrections followed up (*see* para. 216).

GUN TRAINING AND CONVERGENCE (Plate 5)

244. The above corrections are added mechanically to director training in the H.A. table and, combined with convergence, are transmitted away as gun training from the **gun training transmission and convergence unit.**

The diagrammatic arrangement of this unit is shown on Plate 5.

Convergence is applied by following the blue pointer in the convergence unit with the black ; this corrects the gun training transmitted to each gun, the correction to the gun training of No. 1 mounting being shown on the dial.

The convergence corrections are approximately correct in both H.A. and L.A. fire, the range element of the unit being produced from the T.E. gear. The corrections, however, can only be exactly correct for a given angle of sight, and in H.A.C.S. III tables the gear is arranged to be correct at angles of sight approaching 40°, while in H.A.C.S. IIIC tables it is correct for low angles of sight to give a more accurate correction in surface fire.

"*Note.*—For description of the **gun training transmission and convergence unit,** *see* paragraph 249 ". P276/42.

Other functions of the H.A./L.A. C.O.S. (Plate 23)

245. Putting the change-over switches to L.A. also transfers :—

(1) The **fire-buzzer** from the F. and F.I. clock in the H.A. table to the fire gong push in the A.F.C.C.

(2) The **F.O.S. hooter** from the bulkhead F.O.S. instrument at the H.A. table to the A.F.C.C.

OPERATION OF THE CLOCK AND H.A. TABLE

246. The operators for the A.F.C.C. VIII when the guns are being controlled in low angle fire are provided from the crew of the H.A. table.

The duties of the operators are described in Chapter 2 of C.B. 1886. All references to duties in connection with P.I.L. or other units not fitted in this mark of clock should be omitted.

The following operators at the H.A. table remain at their stations for the following duties :—

(*a*) No. 4.—**The deflection screen operator** follows up the red lateral deflection pointer with the black and so adds low angle deflection to director training to produce gun training.

(*b*) No. 6.—**The tangent elevation operator** follows up the red gun range pointer with the black and so adds tangent elevation and dip to director setting to produce gun elevation.

(*c*) No. 2.—**The convergence unit operator** follows the blue pointer with the black, so applying convergence to all guns.

(*d*) The **H.A. system communication number** passes information received from the L.A. communication number to the guns.

(*e*) Numbers 2 and 3 stand by to clutch up hand drives if director transmission fails.

Of the remaining H.A. operators :—

No. 1. Plot operator becomes clock operator (No. 1).

No. 8. Fuze transmitter operator becomes range operator (No. 2).

No. 7. Assistant plot operator becomes communication number (No. 3).

No. 5. A.P.V. operator becomes deflection operator (No. 4).

247. **Lining up.** The procedure for lining up the A.F.C.C., Mark VIII is given in C.B. 1886/34 (4). H.A. and L.A. control systems are lined up together, the procedure for lining up the H.A. table being given in Appendix 5 of the handbook.

Arrangements for Augmenting Fire

248. Augmenting tables, where fitted, receive H.A. deflections, ranges and fuze numbers from the H.A.C.S. tables. Deflections are obtained from additional transmitters on the H.A.C.S. table, vertical and lateral deflection handwheel drives ; range is obtained from a $\frac{1}{R}$ transmitter and fuze number from the gun fuze number transmitters. Change-over switches allow alternative H.A.C.S. tables to supply the information.

" Additional Gun Training Unit with Convergence Gear

249. This unit is provided where it is required to transmit to several guns or groups of guns (up to a maximum of four transmissions) where the displacements of the guns or groups from the director is such that a mean convergence displacement allowance would not be sufficiently accurate. The convergence correction is only added to gun training, no vertical correction being applied.

The unit shown diagrammatically on Plate 5 is contained in a casing standing on its own feet, and secured to the deck, on the left hand side of the table near the screen end. The gun training ' M ' type transmitter usually fitted in the calculating table is omitted, and a gun training drive from the table is suitably coupled to the back of the convergence unit. A flexible tangent elevation + dip height drive is suitably arranged between table and unit.

The tangent elevation + dip drive rotates through a differential, a flat grooved cam, the output lift of which is arranged to impart $\frac{1}{\text{Average Plan Range}}$ effect throw-off to analyser. The cam curve, though giving an average $\frac{1}{\text{Plan Range}}$ from H.A. and L.A. tangent elevation + dip is arranged to favour L.A. conditions. Cams in different units vary for both dip height and ballistic requirements.

The analyser is rotated for gun training, from the incoming drive, through the differential ; thus the output of the analyser is $\frac{\text{Sin B}}{\text{Plan Range}}$.

A drive from an answer pinion, driven by the analyser rack, operates a pointer on a dial on the top of the unit. The dial engraving is so arranged as to indicate the convergence effect applied to No. 1 gun. A follower pointer on the dial is rotated by means of a handwheel on the side of the unit. The handwheel must be pushed in to turn and is automatically locked (normally at zero) when not in use. Suitable stops are provided to limit the handwheel movement.

CHAPTER VIII

THE DIRECTOR

296. The general arrangement of the **Mark III director** is shown on Plates 24A and B. The director is designed for high and low angle control of the H.A. armament through an H.A.C.S. III table.

The **Mark III* director** is designed for high and low angle control of the H.A./L.A. armament through an H.A.C.S. IIIc table used in conjunction with an Admiralty fire control clock, Mark VIII, or a range transmitting clock and deflection calculator. It is fitted with a rate officers position.

The **Mark III** director** is a special type similar to the Mark III and fitted in " Warspite " only.

297. A comparative statement of differences between the Marks III, III* and III** directors is shown in Appendix II, Part A of this handbook. The main difference between these directors and those fitted previously is the replacement of the original 12-ft. heightfinder by a 15-ft. heightfinder mounted in an anti-vibration cradle. The director sight has been redesigned to give more room to accommodate the larger heightfinder.

Crew

298. The crew of the director tower consists of :—

(1) The control officer.
(2) The rate officer (H.A./L.A. only).
(3) Director layer.
(4) Director trainer.
(5) Rangetaker.
(6) Phoneman.

Provision is also made for a second rangetaker in the Mark III* director, and a G.R.U. operator in the later Mark III* directors.

Gear in the Tower

299. 15-ft. U.D.4 rangefinder, desiccator and window cleaning gear.
Director sight with trainer's pistol (also layer's pistol in H.A./L.A. directors).
Control officer's glasses and angle of presentation transmitter.
H.A.D.F.A.S.
Enemy speed transmitter.
Evershed elevation and bearing indicators.
Fall of shot hooter.
Gun-ready lamps (H.A./L.A. only).
" Cease fire " bell.
Communications.
No. 7 dial sight.
Roll compensating oil motor and control gear (in some ships).
Gyro rate unit (in later Mark III* towers only).
Control officer's free binoculars.

RANGEFINDER

300. The rangefinder is of the usual U.D. type with an inverted strip image, and is mounted on the main frame of the tower in a separate anti-vibration mounting.

Instrumental data are :—

Base length	15 ft.
Magnifications	15 and 25 diameters.
Angular field	1° 36′ circular.
Angular height of strip field . .	0° 5′.
Rangefinder scale graduations . .	2,000 to 25,000 yards.
Height scale graduations	1,000 to 30,000 ft.
Movement in elevation	Director setting in use ± 100°.
Viewfinder : Magnification . .	4 diameters.
Angular field . .	10° circular.
Approximate weight of rangefinder	1,350 lb.

301. The rangefinder can be elevated by director or independently by means of a clutch. There are three marks on the " director " and " rangefinder " ring to enable the rangefinder to be lined up with the director in elevation before clutching back to director.

Details of the rangefinder and mounting may be found in the rangefinder handbook.

Protection

302. The tower is made of ·08 inch steel and is only weatherproof. The Mark III** tower is reinforced to withstand gun shock.

Allowances

303. Allowances for dip, M.V., temperature, convergence and drift are made in the table.

Tilt. The standard for tilt is the mean tilt of the gun mountings. The mountings are corrected by packing rings to within $2\frac{1}{2}$ minutes of the mean and the directors are corrected to the standard by means of ordinary tilt correctors, on which tilt up to 10′ on any bearing can be set. No allowance is made for tilt in the elevation or training receivers of purely high angle guns.

ELEVATION AND ANGLE OF SIGHT

304. A diagrammatic arrangement of the director setting and angle of sight drives is shown on Plate 25. The drive for roll correction is provided in all cases but the roll oil unit is only fitted in later Mark III* towers. The **angle of sight handwheel** is fitted for two speeds (3° and $\frac{1}{2}$° a revolution) and where a roll unit is provided, has an autolock to prevent the roll oil motor driving back into the handwheel. The fast and slow mechanical pointers in the angle of sight dial are geared directly to the angle of sight handwheel drive.

305. Where fitted, the allowance for roll is added differentially to the angle of sight drive between the handwheel and the director sight. The roll oil motor is of the standard fire control type, supplied with oil from an electrically driven pump in the roll oil unit (Plate 27). The controlling " A " element is in the gyro roll corrector in the calculating position, the " B " element and recentering transmitter being incorporated in the motor unit (a typical lay-out is shown on Plate 1, Part (A), of the handbook).

Dither is applied by a cam on a shaft geared to the electric motor drive to the pump.

306. The roll motor output drive is added differentially to the movement of the angle of sight handwheel to give director setting which drives the elevating arc, the rangefinder and the Evershed elevation indicator, and, with tilt correction added, the director setting transmitters.

307. **Mechanical stops** (*see* para. 156) limit the output of the roll oil motor to ± 15° and the future angle of sight between 10° depression and 90° elevation.

308. **Oil cut-off gear** for the roll oil motor is arranged, by Arens rod control from the elevating arc to centre the control element hunter and so stop the oil motor when director setting is at 8° depression or 88° elevation irrespective of the angle of roll.

309. When the stops on the director sight engage the lever operating the friction clutch is raised, the plunger is forced in, the tapered part of the plunger forces out on the spring so that the clutch shoes engage with the cut-off cams, and any movement of the resetting transmitter in either direction centres the control element linkage.

310. Any further movement of the angle of sight handwheel raises the operating lever still more but the *driven side* of the friction clutch is held by the mechanical stop and the clutch renders. As soon as the movement of the angle of sight handwheel is reversed the movement of the operating lever and of the friction clutch is reversed, the *driven side* of the clutch recentres, the clutch shoes disengage, and the roll oil motor is immediately freed. The two sides of the friction clutch are subsequently realigned by the other side of the mechanical stop.

311. In some ships an **horizon checking sight** is fitted (*see* Note (iii), Appendix II, Part (A), of this handbook.) A flexible drive from the roll oil motor shafting positions the periscope mirror. The telephone operator can align the sight with the horizon by the correction-to-roll handwheel, which alters the angle of roll transmitted from the gyro roll corrector to the roll oil motor (*see* Part (A), Chapter III). With angle of roll and angle of sight set to zero the horizon checking sight mirror can be aligned with the director telescopes for elevation by means of the two adjustable screws (one for the front and one for the back horizon) on which the mirror bears.

TRAINING GEAR

312. A diagrammatic arrangement of the director training gear is shown on Plate 26. The **director training handwheel** is fitted for two speeds ; in the normal position one revolution of the handwheel gives 1° of training. In the fast training position with the thumbpush in the handle depressed, one revolution gives 10° of training.

The layer's training handwheel is similar to the trainer's wheel except that it is only fitted for high speed training and is disconnected from the training position unless the thumbpush is depressed. It has been done away with in Marks III* and III** directors.

313. The weight of the tower is taken on the **ring frame,** carried by rollers running on a roller path.

314. The director trainer can read the relative bearing off the bearing racer through a hole in the **ring frame,** and an **Evershed bearing receiver** is driven off the training pinion. A director layer's **bearing indicator** is driven off the training rack in conjunction with a **training limit stop** which limits the arc of training to approximately 356° in either direction. The stop is controlled by a crank which forces it out to take against a fixed stop on the director pedestal once every 360°.

315. A **spring locking bolt,** actuated by a lever on the right of the trainer's position, can lock the tower in the securing position. In most towers there are alternative securing positions, locking brackets being bolted to the fixed pedestal as necessary.

DIRECTOR TELESCOPES

316. The layer's and trainer's telescopes are mounted in carrier arms rigidly secured to an elevating pivot carried in the **main frame** of the director, the weight of the telescopes being balanced by a torsion spring inside the elevating pivot shaft. The telescope carrier arms are cross-connected and are adjustable, the layers for elevation and the trainers for training, up to a maximum of 40 minutes, by means of eccentric bolts in the telescope carriers.

FIRING PISTOL

317. A trainers firing pistol is fitted to the main frame in all directors and an additional layer's pistol is fitted in H.A./L.A. directors.

CONTROL OFFICER'S GLASSES AND ANGLE OF PRESENTATION GEAR

318. **The control officer's glasses** are carried on a bracket which is moved in elevation by a link and lever keyed to the elevating pivot. The glasses can be adjusted for elevation and training by eccentric bolts.

318A.

319. Two angles of presentation graticules are fitted on the right-hand glass of the control officer's binoculars. The **full graticule** is driven by a flexible drive from the angle of presentation handwheel and is aligned by the control officer with the track of aeroplane. Movement of the angle of presentation handwheel also moves the **broken graticule,** the controlling transmitter and the mechanical pointer of the table presentation receiver. An angle of presentation **spotting knob** can be used to impose a spotting correction on the handwheel drive. This additional movement is imparted to the broken graticule and the transmitter. The two graticules make it easier for the control officer to visualise his " spotting angle " and to follow changes in angle of presentation caused by change of relative bearing or small alterations of course.

320. When G.R.U.B. is installed the following changes are made to the angle of presentation system in the H.A. Director :—

(*a*) Only one graticule is used and this is arranged for reception from the G.R.U.B. of angle of presentation by step-by-step motor.

(*b*) The angle of presentation handwheel only controls a transmitter which applies corrections to the G.R.U.B. and the setting actually applied is seen in the binoculars by the reception at (*a*).

Further particulars are given in Part F of this handbook.

TARGET SPEED

321. Aircraft's speed is set by hand on the **target speed dial** and controls the *u*/A.P.V. power follow up. A red pointer indicates table target speed. When G.R.U.B. is fitted, certain amendments are made which are described in Part (F) of this handbook.

HIGH ANGLE DIRECTOR FORWARD AREA SIGHT (H.A.D.F.A.S.)

322. The H.A.D.F.A.S. is mounted on the control officer's bracket, and can be aligned with the director telescopes for elevation and training by means of eccentric bolts.

323. The sight consists of a telescope fitted with a spider's web graticule, and can be moved relative to the director sight by separate vertical and lateral deflection handwheels. These deflection movements, which are limited by stop gear to 6° in either direction, are communicated by " M " type transmitters to special projectors at the deflection screen.

324. The graticule is made up of a 5° circle intersected by spokes every 30°.

325. Free binoculars for the control officer are mounted on the main frame. Through flexible drives their movement for elevation and training is communicated to indicators at the layer's and trainer's positions respectively. When not in use they can be locked clear of the control officer's bracket, and cam gear is fitted to force the glasses clear should they be in a position to foul the director sight.

325A

BOMBARDMENT

326. Bombardment levels and No. 7 dial sights are provided. The level fits on a mandrel which can be clamped in the layer's telescope bracket, and the dial sight is mounted on the main frame.

RECEIVERS

Paragraph 327. *Delete* whole paragraph *except* heading " **Receivers** " and *substitute :*
" *See* Appendix VIII."